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ORIGINAL PAPER

Learners' socio-cultural backgrounds and science teaching and learning: a case study of township schools in South Africa

Lydia Mavuru[1] · Umesh Ramnarain[1]

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Abstract

In an effort to pursue and achieve quality and equity in science education, the South African National Curriculum Statement stipulates that learners should be accorded an opportunity to acquire and apply knowledge and skills in meaningful ways. Accordingly, the curriculum promotes knowledge in both local and global contexts. The study investigated how teachers' knowledge of learners' socio-cultural backgrounds is invoked in enacting various teaching and learning approaches that bring relevance of science to learners. Three science teachers from three township high schools were observed teaching while incorporating learners' socio-cultural practices, experiences and beliefs when teaching the topics reproduction, nutrition and healthy diet. The teachers were interviewed after each lesson via a closed-ended protocol. Science local curriculum documents and lesson plans were also analysed. A total of five lesson observations and five post-lesson interviews per teacher were analysed using the constant comparative method. The findings revealed that teachers use probing and open-ended questions, argumentation in groups, authentic problem-solving activities and resources, examples, experiences and language familiar to learners. Such practices promote class and group interaction, develop critical and analytical thinking skills in learners and promote conceptual understanding. The research findings provide insights into how certain science topics can be taught in meaningful ways to socio-economically and culturally diverse learners, which can contribute to the current debate on relevant education in a country faced with huge diversity.

Keywords Socio-cultural background · Township schools · Argumentation · Authentic problems · Critical and analytical thinking

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✉ Lydia Mavuru
lydiam@uj.ac.za

Umesh Ramnarain
uramnarain@uj.ac.za

1 Department of Science and Technology Education, University of Johannesburg, Johannesburg, South Africa

When provided with contextually relevant science education, learners are developed with the knowledge, skills and values, which they can apply in their lives due to relevance (Darling-Hammond, Austin, Lit and Nasir 2003). Tan (2011) found out that when teachers are sensitive to learners' cultural norms and values, learners tend to engage meaningfully with the tasks, and ultimately, learner performance improves. Further, some authors speculate that the persistently poor performance in science in South Africa could be due to *foreign* classroom contexts, which do not reflect the lived experiences of learners (Msimanga and Shizha 2014). Others argue that when science teachers incorporate Indigenous Knowledge (IK) into their teaching, science is demystified because it becomes grounded in familiar homegrown knowledge and learners' culture (Asabere-Ameyaw, Dei and Raheem 2012). As a result, the learners realise that the knowledge is not alien to their cosmological knowing and they feel included. This refers to learners being able to identify themselves and understand what they learn within the framework of their cultural and belief systems.

Many researchers have indicated the important role that learners' socio-cultural backgrounds play in influencing science teaching and learning and have similarly justified its inclusion into the science curriculum. These justifications are rooted in a widely held appreciation of the importance of the context of science learning and its influence on meaningful learning (Kalolo 2015). In addition, learner's prior knowledge brought to the science classroom is constructed from those learners' observations and experiences of their religious beliefs and societal customs (Akpanglo-Nartey, Asabere-Ameyaw, Sefa, Dei and Taale 2012). Research has also shown an apparent discontinuity between learners' cultural norms and values acquired from home, and those that guide learners' behaviour once they enter the science classroom, with the result that learners do not realise how valuable and relevant the school science is in their daily lives (Tyler, Boykin, Miller and Hurley 2006).

South African education reforms envision a schooling system in which all learners from all backgrounds are accorded the opportunity to succeed (Frempong, Reddy and Kanjee 2011). A point to note is that there is a deficit positioning of learners' socio-cultural practices, experiences and beliefs by some of the teachers. As such, despite calls for reform, teachers have shied away from incorporating learners' cultural capital into their teaching. The integration of learners' socio-cultural backgrounds has been a challenge to teachers, as there has been no specific directive on how it can be implemented (Otulaja, Cameron and Msimanga 2011). In addition, there exists a dearth in specific empirical evidence on the types of teaching strategies, or methodologies, and the content that teachers should use when incorporating learners' socio-cultural backgrounds. As such, learners label science as *elitist* since the content, and how it is taught, is divorced from their worldviews.

With regard to the above, this study aims to illustrate how teachers can incorporate learners' socio-cultural backgrounds when teaching reproduction, nutrition and a healthy diet to early high school learners. The current study posits that teachers' knowledge and incorporation of learners' socio-cultural context could shape the way they teach in their science classrooms, particularly the nature and levels of questions asked, the ideas reinforced in the content, the activities assigned to learners and the instructional strategies employed. When teachers integrate learners' socio-cultural backgrounds into science teaching, it creates socio-constructivist science classrooms as Lev Vygotsky (1978) emphasises the critical importance of culture and social context for cognitive development. It is assumed that learners become active participants in the learning process and that learning is the result of an interactive engagement with authentic problems, which provide opportunities for learners to construct their own knowledge. In essence, the recognition and inclusion of learners' worldviews do not simply mean collecting their values and beliefs, but rather it also depicts how learners view and experience their own lives. This is defined as good teaching (Nisbett

2003), which is pertinent because deficiency in appropriate guided learning experiences and social interaction obstructs learning and development in learners (Bransford, Brown and Cocking 2003).

The study's line of argument

Around the middle of twentieth century (1960s and 1970s), science was regarded as factual, universal and value-free. Previous research (e.g. Kalolo 2015) bemoaned that in most African countries science is still regarded as universal. Such a notion disregards the nature of science. This is more for the tenets which contend that scientific knowledge is inferential, creative, and socially and culturally embedded (Schwartz and Lederman 2008). Nature of science refers to one's perceptions of how scientific knowledge is developed (Lederman, Lederman and Antink 2013). Later in the twentieth century, science has been conceptualised as a subculture of the western culture (Hewson and Hewson 1988; Jegede 1995; Aikenhead 1996). Such a conceptualisation meant that learners from other traditional cultures perceived themselves as outsiders and not feel included in the "compulsory" subject, which of course is important as a driver in economic growth in most nations.

Seiler (2001) underscored the importance of IK as learners' cultural commodities, which are their forms of capital that needs to be respected and valued. Addressing issues of relevance of science to learners' everyday life is of utmost importance as this may influence learners' motivation to continue studying science. By studying science, learners attain scientific literacy which then informs the decisions they make in approaching problems that affect them and society at large (Lederman, Lederman and Antink 2013). If that is the case, how then can learners utilise the knowledge and skills from science if it is divorced from their socio-cultural background?

The study does not advocate for the disregard of scientific principles in the science classrooms; neither does it argue for the replacement of scientific knowledge with indigenous knowledge. Rather, the focus is on finding ways of using both knowledge domains, science and indigenous knowledge in order to equip learners with knowledge and skills that articulate clearly the applicability of such acquisition in their daily lives. By integrating the two "knowledges", learners are not only likely to understand scientific concepts better; they would also appreciate it as science would be evident in their worldviews. Worldviews refer to the learners' beliefs, perceptions, experiences and the value judgements they bring to the science classroom (Liu 2007), referred in the context of the current study as learners' socio-cultural background. As such, science then explains some of the issues not explained by indigenous knowledge and the reverse would be true. Learners would make informed decisions if the science they learn is meaningful and relevant in their lives.

The overarching argument in the current study is that by integrating science and indigenous knowledge in the science classroom, learners develop a holistic lens through which they view science. As such, learners are likely to understand scientific concepts better and at the same time value and embrace their socio-cultural background. Lederman, Lederman and Antink (2013) alluded to the relationship that exists between learners' worldviews and their conceptions of science. It therefore means that if learners' worldviews are ignored in the process of teaching and learning of science, this has an impact on learners' conceptual understanding. Learners' socio-cultural background should provide the context in which science is taught so that learners relate to science in their daily lives and at the same time discern for themselves the limitations of both science and their indigenous knowledge.

Such a stance strengthens Mboya's (1999) view that learners should not assimilate the science they are taught, but rather the science knowledge acquired should enhance their IK.

Authors' arguments and assertions about the need for integration of learners' socio-cultural background in science teaching and learning are based on their experiences as science students in high school and university, and as educators in both high schools and universities. In particular, as the first author, my experiences of learning science in a language different from my own and learning of scientific processes and even using equipment that are farfetched or not relatable to my everyday experiences created an elitist view of science in me. The situation was made worse because the diversity in such science classrooms was overwhelming in terms of race, language, religion and socio-economic backgrounds. Teachers, lecturers and textbooks did not make it easier either because science was portrayed as a difficulty subject, which only the clever ones could succeed in. Surprisingly, the situation is still perpetuated up to this day because there has not been concerted effort in research to document classroom practices where teachers integrate learners' socio-cultural background in the science classrooms.

At the advent of independence in most African countries, indigenous people viewed science as having been imposed on them with the goal of institutionalising the western values, beliefs, language and western epistemologies (Odora-Hoppers 2001). Such sentiments were also echoed by Maddock (1983) who pointed the manner in which western science displaces the cultural practices of indigenous people, which Kalolo (2015) described as the alienating effect. Kalolo reiterates that the discord between science and IK was created as a result of implementers' (teachers included) failure to integrate the two knowledge domains. Therefore, the teachers' role is to articulate the relation as they teach. In that regard, science teachers should develop learners into appreciating their socio-cultural knowledge, beliefs and practices because their communities' livelihood and development are based on that. By disregarding own knowledge and wisdom, communities and learners would lose their cultural capital, which could be misrepresented in the long run (Battiste 2002). In any case, integration of various learners' socio-cultural backgrounds in the science classrooms helps in enhancing cross-cultural understanding and tolerance in learners and ultimately view things from multiple perspectives.

To bridge the gap between science and learners' socio-cultural background, different authors advocated for culturally relevant, culturally responsive, contextually relevant and culturally sustainable pedagogies (e.g. Gay 2000; Ladson-Billings 1995) and culturally appropriate instruction (Dei 2012). Such teaching strategies provide a bridge through which learners' socio-cultural experiences are utilised in the science classrooms in order to bring meaning, applicability and connectedness of science concepts to learners' lived experiences at home and in the communities. This could be done through the use of learners' home languages, examples and resources familiar to learners during the teaching and learning process (Gay 2000).

Learners' socio-cultural backgrounds and science teaching and learning

Core to learners' socio-cultural backgrounds is the Indigenous Knowledge (IK) possessed by them. Grenier (1998) described IK as the knowledge and skills possessed by people living in a particular geographical area, which enables those people to utilise their natural environment fully and obtain benefits from it. Indigenous Knowledge Systems (IKS) can be defined as "a conglomeration of knowledge systems encompassing science, technology, religion, language, philosophy, politics and other socio-economic systems" (Ogunniyi 2007, p. 965). A point to note is that the integration of IK into modern science classrooms has been described as complex (Mpofu, Otulaja and Mushayikwa 2013). Too much responsibility is thrust upon teachers, particularly in South Africa where the curriculum fails to provide the much needed pedagogical guidelines for them to follow. Therefore, science teachers remain faced with insurmountable tasks to firstly recognise and understand diversity in learners' socio-cultural backgrounds in the classroom; secondly, to select appropriate knowledge for integration with particular science content; and thirdly, to identify the most suitable ways that learner differences can be managed to ensure learner effective engagement with science concepts.

It has been noted that when teachers plan and teach science while considering learners' socio-cultural backgrounds, the teaching and learning process becomes more learner centred (Abah, Mashebe and Denuga 2015). In concurrence, Mavuru and Ramnarain (2017) found that science teachers view the incorporation of learners' socio-cultural backgrounds as providing learners with an opportunity to develop skills in critiquing and analysing problems and activities provided in the learning situation. However, there has been no consensus on the appropriate teaching strategies for the incorporation of learners' socio-cultural backgrounds into science lessons. Argumentation provides a possible strategy as it engages learners in interpersonal interactions and discussions, thus giving learners an opportunity to evaluate the "usefulness and fruitfulness" of different ideas, which equips them with skills to recognise and appreciate the validity of their worldviews (Ogunniyi 2004).

Before exploring about the suitability of argumentation as a strategy when integrating learners' socio-cultural background and science, it is important to enlighten readers of the nature of African indigenous societies. Unlike in the Western tradition where bureaucracy matters, the following are the characteristics of African indigenous societies: decisions are collectively made, there are group structures where all are valued, authority is endorsed on the elders automatically, time management is flexible, and formality in everyday dealings is not upheld (Barnhardt 2002).

Argumentation therefore has been criticised as *unAfrican* as it juxtaposes the African values of communality, group participation, sharing and respecting others (Hewson 2015). In as much as argumentation enables learners to communicate knowledge through social interaction (Duschl 2008), it also requires them to develop, evaluate and validate knowledge (Driver, Newton and Osborne 2000). This provides a predicament in the science classrooms when learners' socio-cultural belief systems and practices fail to meet the requirements. Both the teacher and learners become conflicted in openly refuting the validity of such knowledge, which can be taken as "denouncing" other people's beliefs. In fact, those who hold such belief systems are likely to be offended. It therefore means that other learners' beliefs would be compared with others and science knowledge. While scientific argumentation is based on the scientific evidence which is more meaningful than the ones given by the other, there are views that open-mindedness, which is essential in science learning, conflicts with religious faith from the scriptures and religious leaders (Good 2001). It was also found that such a viewpoint emphasised acceptance of dogma (such as long held scientific assumptions) and rituals (in the case of religion) without question, thereby negatively influencing learners' perceptions of the benefits of religion and school science (Koul 2003). It therefore means that convincing others to accept or proffer a view (McNeill and Pimentel 2010) will be considered unAfrican. Because sense making and persuasion (Berland and Reiser 2009) are characteristics, typical of an argumentation, bias and confrontations may arise (Faize, Husain and Nisar 2018). Such situations are unAfrican in our view, considering that social cohesion and consensus are the value systems promoted in the African culture.

Tailored teaching strategies have also been suggested as an appropriate means of integrating learners' socio-cultural knowledge with science knowledge (Hewson 2015). The strategies suggested above all point towards culturally and contextually responsive science teaching and learning, which help to build scaffolds between learners' home and school experiences, and lived socio-cultural realities and scientific knowledge (Gay 2000).

A point to note is that cultures differ, and as such, learners find themselves upholding different worldviews that influence how education should be practised (Ho, Holmes and Cooper 2004). Accordingly, Wellington and Osborne (2001) noted that the language of teaching and learning, learners' prior knowledge, their behaviour and the way they view phenomena and most importantly the things they value in life may enhance or impede how learners interact or participate in class. Both researchers and teachers should be aware and accept that spiritual beliefs are wide ranging and form a rich part of learners' lives. As such, teachers should take upon themselves as guides to ensure the knowledge, experiences and beliefs learners bring to the science classrooms are utilised positively to enhance learner understanding. A point to note is that pedagogical strategies and activities teachers use should embrace every learner rather than marginalising them.

What constitutes as South African indigenous knowledge?

Based on the foregrounded arguments outlined already this section briefly presents what constitutes the South African indigenous knowledge and ultimately provides an understanding of the South African learners' worldviews. This is important because different communities have their own way of life and conception of the world around them, which they use as a lens to formulate opinions, attitudes and ultimately knowledge.

The South African and African people at large have their own belief systems that are ingrained in their cultural perspectives, experiences, language and customs. These include the belief in the spiritual realm, which Kaya and Seleti (2013) referred to as spiritual heritage. Most people believe and have confidence in the work of traditional healers who because of knowledge of the characteristics and theory of specific plant species they get to cure particular diseases that inflict people (Kaya and Seleti 2013). This is consistent with studies that found that the use of traditional medicine remains popular in most regions of the developing world even amongst people with access to modern health facilities (Gari, Tarlagadda and Wolde-Mariam 2015). Even the Geneva World Health Organisation (2001) showed that in Africa, 80% of the population uses traditional medicine. Some of the African ways of knowing and teaching involves initiation of both girls and boys through different stages of adulthood, indigenous games, agricultural systems, dances and songs, storytelling and proverbs (Kaya and Seleti 2013). According to Noyoo (2007), the success of the sustainable conservation of nature in some of the African traditions is as a result of respect for nature, moral attitudes towards nature, restraint in resource exploitation and mutual co-operation. As such, education is meant to promote sustainable development of the communities in which learners live.

Another important aspect of the South African people's indigenous knowledge lies in how they relate to each other, a concept called "ubuntu". The philosophy of Ubuntu and belief in the supreme being are important ideological and relational references in the lives of South Africans and Africans at large. Ubuntu is captioned by what Desmond Tutu, a

South African religious icon, said, "I am because I belong", as a way of acknowledging the importance of coexistence with one another. Ubuntu embodies one's abilities to share and reciprocate with good deeds to ensure people live in total harmony. Ideally, the African tradition recommends that people should be respectful and cooperative rather than being competitive (Odora Hoppers 2002), which then needs to transcend in all contexts of life, the science classroom included. Coined as a rainbow nation, South Africa has diverse groups of people, cultures and religions. However, this study will only explore the traditional African beliefs since the scope of the paper is on IK. South Africans who believe in the African traditional religion worship ancestors who are the connection between the living and the Supreme being, God. In a general household survey done in 2013, 5% of South African population indicated that they practise ancestral or traditional African religion (Schoeman 2017). It should be noted that even though some people may be Christians, they still regard their ancestors as mediators between African people's descendants and God (Bae 2007). It is believed that ancestral spirits potentially wield power that benefit the living if respected and venerated properly and can afflict pain on the living if veneration is neglected (Mitchell 1977). Even in times of tribulations, Africans have remained resilient due to the belief that their ancestors provide them with strength, intellect and self-assurance (Afeke and Verster 2004).

An extensive review of literature revealed that the socio-cultural dimension is inclusive of four aspects. These are norms and values; religion and beliefs; socio-economic and political issues; and science knowledge and technology (Mavuru and Ramnarain 2017). Figure 1 shows the study's conceptualisation of learners' socio-cultural background.

Cultural norms are attitudes and behaviours that a particular group of people uphold, and values refer to what a cultural group of people considers important (Hall 2007). Both norms and values constitute an individual's worldview which provides the *cognitive lens*

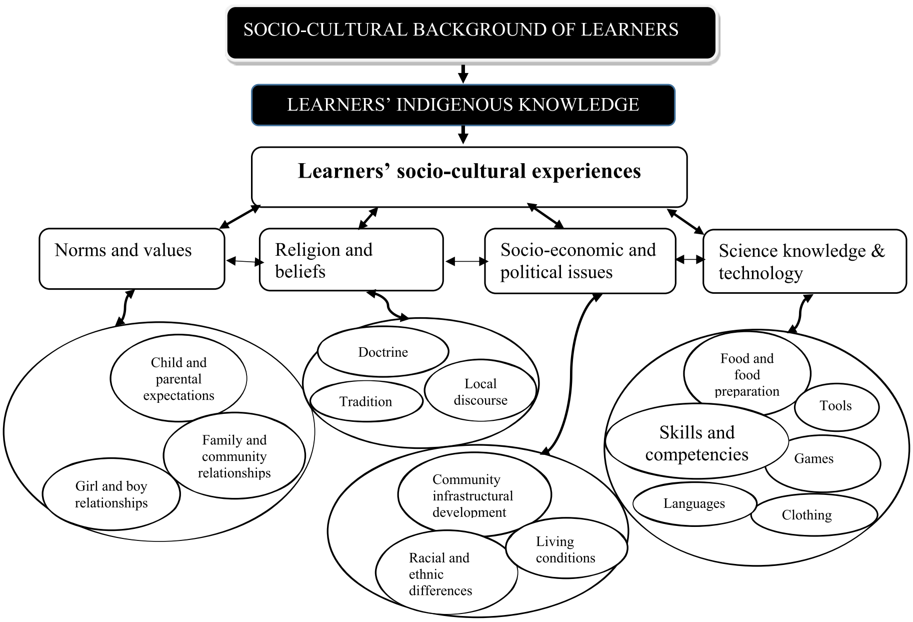

Fig. 1 Interrogating learners' socio-cultural backgrounds. (Adopted and adapted from Mavuru and Ramnarain 2017)

through which the individual views and interprets phenomena (Lee 1999). Boykin, Tyler and Miller (2005) noted that learners' home-based cultural norms and values that guide their behaviour can lose authority once they enter the science classroom, which makes it difficult for learners to adjust. This is because the learners' socio-cultural practices are different from those of the majority culture of the classroom, and hence, this home culture is undervalued. Such cultural discontinuity could be the reason for academic difficulties faced by these learners (Wong and Rowley 2001). This is the reason why the current study argues for the incorporation of learners' socio-cultural background in the science classroom.

Some researchers found that the incorporation of learners' cultural norms and values into lessons and class activities could facilitate learner performance (Serpell, Boykin, Madhere and Nasim 2006) due to learners being more engaged with these familiar activities (Rogoff 2003). In a study to capture African American learners' cultural preferences for learning behaviours that influence how much the cognitive skills develop, Tyler, Boykin, Miller and Hurley (2006) found that both learners and their parents strongly preferred communal and vervistic activities more than individualistic and competitive activities. Such preferences were displayed both at home and school. In this case, communal refers to how people depend on each other and how they focus on sharing and performing tasks for the benefit of the whole group (Boykin 1983), as opposed to being individualistic and competitive. Vervistic behaviours refer to responsiveness to, and bearing towards, high levels of sensitivity to stimuli (Tyler et al. 2006), which mean that classroom activities set should interest the learners.

In differentiating between religion and science, it can be argued that open-mindedness, which is essential in science learning, clashes at all times with religious faith from the scriptures and religious leaders (Good 2001). As such, Roth and Alexander's (1997) study showed that many USA and Canada learners who have strong religious beliefs are likely to harbour negative attitudes towards school science. It was found that such learners had difficulties in learning science or even to choose science-related careers. This is explained by some researchers who hold views that learners bring to the science classroom some socio-cultural beliefs that create gaps between what they are taught and what they learn (Ogunniyi 1988), which in our view is a deficit positioning of learners' socio-cultural beliefs. A point to note is that learners' religious beliefs may defy knowledge and reasoning from science and, consequently, learners fail to deduce the appropriate knowledge to consider. In a study involving Nigerian junior secondary school learners, Ogunniyi (1988) found that the way learners understand biology concepts is highly influenced by the religious beliefs they hold. However, to ignore spirituality in the science classroom is not an option because it explains how humans and nature depend on each other and how various groups of indigenous African people exist (Msimanga and Shizha 2014). The view of the authors in the current study is that learners have important and different religious systems, which form a rich base for the teaching and learning of different science concepts, particularly if teachers employ appropriate pedagogical strategies.

On socio-economic and political issues, Jay Lemke (2001) posits that when science concepts are taught without reference to how they are influenced by the socio-economic, historical, political and technological contexts, it falsifies the nature of science. Lemke questioned the usefulness of scientific literacy to learners as citizens if they are not taught about historical origins of these concepts or their economic impact. Studies indicate that the socio-economic status (SES) of families is a factor in learner achievement at school (e.g. Van der Berg and Burger 2003). This could be attributed to the deficit model of parenting (Harper 2015), where some learners from socially disadvantaged backgrounds perform poorly in science because both the parents and the children have low ambitions

(Gutman and Akerman 2008). This is contrary to the views of other authors, who have found that both parents and children from poor socio-economic backgrounds are highly inspired to achieve better (Kintrea, Clair and Houston 2011). The findings of a study on socio-economic and political issues, which explored equity and quality education in South Africa, advocated for a capability framework where every learner should be included, and given an opportunity to participate fully in the learning process (Frempong, Reddy and Kanjee 2011). Their study proposed the use of learner-centred approaches, which form the main principles of providing meaningful education to learners from all backgrounds. These authors used a framework based on Amartya Sen (1999), who contends that the success of the poor in education is dependent on the ability to transform teaching and learning resources for the benefit of the learners. Teachers, therefore, should create an encouraging learning environment and provide relevant content and learning processes (Pigozzi 2008).

The science knowledge and technology in the framework in Fig. 1 encompass cultural science knowledge, which borrows some aspects from Western science knowledge that is utilised in some communities. Indigenous people from Africa possess scientific knowledge and skills, which they perpetuate through involving their children in cultural practices and talk (Fien 2006). In concurrence, Emeagwali (2003) noted that people benefit from such knowledge when they use it in agriculture, preparing food, taking care of the sick, teaching the next generation and conserving natural resources for sustainable development of their communities.

The fusion of both English and indigenous languages in science instruction is important as English has been found to be the greatest impediment to science learning, particularly for the marginalised learners (Henderson and Wellington 1998). In that regard, the use of indigenous languages can support learners (Meyer and Crawford 2011) since language communicates the traditions, customs, and the morals and values of a people (Lemke 2001). The above authors advocate for the teaching and assessment which provides equal opportunities for diverse learners, by considering learners' socio-cultural experiences, languages and the local discourse, thus allowing learners to maintain their identities. The consideration of learners' socio-cultural backgrounds when teaching science is key to effective teaching, so that science learning can be relevant and meaningful to learners. The research reported in this article is especially pertinent to South Africa where education reform, in the new democratic order since the dismantling of apartheid, envisions an education system, which ensures success of all learners from different backgrounds (Frempong, Reddy and Kanjee 2011). It is against this vision that the current study explores the pedagogies teachers employ when integrating learners' socio-cultural perspectives into science in an effort to provide relevant and meaningful science learning experiences.

Purposive sampling as a method

In this research, a qualitative case study design was deemed appropriate to explore the processes and dynamics of teachers' practices (Gall, Gall and Borg 2003) when incorporating learners' socio-cultural backgrounds into Natural Sciences teaching. Purposeful sampling (Patton 2002) was used in selecting three Natural Sciences teachers from three different township schools.

The teachers were part of a larger group of teachers who had undergone professional development at a university in the integration of indigenous knowledge into science teaching. The additional criteria imposed required teachers to have taught Natural

Sciences in those same township schools for 3 years; teachers who sought further professional development; and who displayed an interest in the study. *Township schools are those* learning institutions which were assigned for Blacks in disadvantaged urban areas during apartheid era in South Africa. A point to note is that in as much as the South African government has tried to integrate people of different races in different schools after the achievement of democracy in 1994, the demographic patterns in schools have not changed much (Chisholm and Sujee 2006) and, as such, mainly Black African learners make the population in township schools.

Research setting

Thendo, Pedro and Nhlapo (pseudonyms) are the participant teachers in three high schools in the south-western part of Johannesburg, one of the 15 districts in Gauteng Province of South Africa. The schools are located in the same community. The enrolment of learners at Thendo's, Pedro's and Nhlapo's schools was around 1300, 1280 and 1100 Black African learners, respectively. The schools draw learners from poor socio-economic conditions such as informal settlements with no infrastructural development. The learners originate from four ethnic groups: Zulu, Xhosa, Sotho, Pedi, and over the years, the participant teachers have learned to speak their learners' home languages. In most homes, the parents were either unemployed or had low-paying jobs such as domestic and construction work. It is difficult to separate the influence of school and community because there is a close resemblance between the socio-economic profile of a school and that of the community where the learners live (Van der Berg et al. 2011). Under normal circumstances, the school reflects the nature of the community it serves in terms of socio-cultural norms and values, and the socio-economic status. It is, however, unfortunate that in certain instances, teachers prefer to promote western cultures at the expense of what the learners bring to the science classrooms. It is therefore the duty of the teachers to create opportunities for the learners, particularly from socio-economically disadvantaged homes, by tapping on what they bring to the science classroom and utilise to the learners' advantage. In a study on teachers' knowledge and views on the use of learners' socio-cultural background, Mavuru and Ramnarain (2017) found that when teachers acknowledged the importance of using resources and examples familiar to learners from disadvantaged communities, learner interest in science was stimulated. Teachers in the study did not perceive the deprived backgrounds of learners as a stumbling block but saw an opportunity to make their learning experiences more authentic and relevant. Teachers can therefore ensure inclusivity in the science classroom if they plan for diversity (Department of Basic Education 2011). As such, teachers should avoid a deficit perspective, which views diversity as a barrier to learning, but rather use learners' socio-cultural backgrounds to optimise a learning opportunity.

In South Africa, schools are categorised according to quintiles for purposes of education funding. In the quintile 1, 2 and 3 schools which are located in impoverished communities, learners do not pay any school fees. This is unlike the quintile 4 and 5 schools which are located in affluent communities, where learners pay school fees. The three schools that formed the focus of this study are quintile 1 schools which depend on government support in terms of resources since no school fees are paid. Table 1 indicates the three participant teachers' profiles.

Table 1 Teacher profiles

Teachers (pseudonyms)	Thendo	Pedro	Nhlapo
Gender	Female	Male	Male
Age	26	43	58
Ethnic group	Pedi	Zulu	Tsonga
Religion	Christianity	Christianity	Christianity
Qualifications	Bachelor of education	Higher diploma in education	Diploma in education
Subject specialisation	Natural sciences and physical sciences	Zoology, botany and chemistry	Life sciences
Teaching experience	4 years	13 years	33 years
Average class size	42	45	50

Professional development programme

The researchers designed and implemented a professional development programme for the enhancement of the teachers' pedagogy in teaching Natural Sciences topics that incorporated IKS. Throughout the professional development process, the researchers mentored the teachers. The concept map depicted in Fig. 1 was used to orientate and engage teachers in discussion on how their learners' socio-cultural backgrounds could be integrated into the teaching of science. Ideas that emanated from these discussions directed the joint planning of lessons for the teaching of selected topics from the curriculum.

After each lesson, through stimulated recall, the teachers reflected on the lesson. Here, focused questions on the integration of learners' socio-cultural backgrounds enabled the teachers to reflect on, and analyse, their practices in terms of curriculum design principles such as the instructional process, the role of the teacher, role of learner and assessment (Schiro 2013). The researchers also shared their notes on the lesson and offered advice when appropriate. When teachers displayed any uncertainty about their competency due to their inexperience with these new teaching approaches, the researchers encouraged them to persevere. Michelle Gregoire (2003) explained such feelings of uncertainty by teachers when she said that teachers consider new practices if they do not view the change as a threat but rather as a promising challenge. The professional development process is described in Table 2.

Using data to explore classroom practices

Data collection involved an in-depth exploration of classroom practices through lesson observations, post-lesson interviews and analysis of documents such as science curriculum documents, lesson plans, learner workbooks and assessment tasks assigned to learners. A non-participant observation method was used to capture real classroom practices. The capture and analysis of classroom observation data were guided by the Reformed Teaching Observation Protocol (RTOP) (Sawada, Piburn, Falconer, Turley, Benford and Bloom 2000). RTOP measures the extent to which a classroom teacher engages in teaching strategies that build learner content knowledge in a manner consistent with reformed teaching approaches. In this case, reformed teaching referred to the incorporation of learners'

Table 2 Structure of the professional development process

Stage	Activities	Resources
1	Researchers used a concept map of the study's conception of learners' socio-cultural backgrounds, which was discussed with teachers Using a brainstorming approach to what constitutes learners' socio-cultural backgrounds, the concept map was modified as presented in Fig. 1. This process involved both the researchers and the three participating teachers	Concept map showing learners' socio-cultural backgrounds as shown in Fig. 1
2	Researchers designed activities—based on teachers' knowledge of their learners' socio-cultural experiences, practices and beliefs—that were suitable for incorporation into selected Natural Sciences topics Teachers identified suitable methods and designed activities for the incorporation of learners' socio-cultural backgrounds into natural sciences teaching	Concept map Curriculum documents
3	Researchers provided a lesson plan template, which teachers used to plan lessons that incorporated learners' socio-cultural practices, experiences and beliefs into selected natural sciences topics	Curriculum documents, Learners' science textbooks
4	The researchers and the teachers evaluated the teaching strategies and activities used in the previous lessons and identified ways of improving future lessons	Video clips of previous lessons

socio-cultural practices, experiences and beliefs in science teaching. Each teacher was observed on five occasions when teaching different concepts on reproduction, nutrition and healthy diet.

Lessons from observations and interviews

The lesson analysis was framed according to five target elements as specified in the RTOP. These targets included how the teachers designed and implemented their lessons, propositional knowledge, procedural knowledge, the patterns of interactions displayed in the communication and learner–teacher relationships (Sawada et al. 2000).

Lessons were videotaped, transcribed and analysed by identifying and describing evidence for each of the five target elements in the RTOP. The researchers interviewed each teacher after a lesson so that the teacher could clarify and elaborate on the practices observed when teaching. The researchers prompted the teachers to recall excerpts by playing the video clip of the lesson. The teachers were asked to comment or justify decisions made, such as the teaching strategy employed, activity provided, questions asked and responses given. In addition, science curriculum documents, lesson plans for the observed lessons, five learners' workbooks from each teacher and teachers' journals written during the research were analysed in order to corroborate the classroom observation and interview data. The researchers used constant comparative method (Merriam 1998) to analyse data obtained from post-lesson interviews and the analysis of documents. This method requires researchers to first identify issues or incidents in the lesson plans; these same issues are sought out during lesson observation and again raised in the post-lesson interviews. These were then compared constantly within and between levels of conceptualisation until a theme could be formulated (Merriam 1998). Analysis involved a continuous and ongoing process where themes that initially developed were either improved, established or even discarded if new data emerged later on.

Interview transcripts and documents were coded by applying manual coding (Saldana 2009). Coding was done inductively as coding categories emerged from the data and were not predetermined. In addressing dependability of the data analysis, coding was done as soon as data were collected. Recoding followed after some time, and finally, results were compared (Fereday and Muir-Cochrane 2006). This was meant to check for consistency thereby ensuring accuracy. Teachers were given an opportunity to react and to respond to the researchers' analysis and interpretations to enhance credibility of the study.

Teachers' use of learners' socio-cultural background as a tool

Research findings show four main themes on the strategies teachers employed when incorporating learners' socio-cultural backgrounds into the teaching of some Natural Sciences topics. These themes portray the extent to which the integration of learners' socio-cultural backgrounds shifted classroom instruction from traditional teacher-centred, lecture-driven instruction (MacIsaac and Falconer 2002) to learner-centred teaching (Lawson et al. 2002). These pedagogical practices helped teachers to elicit learners' alternative conceptions, stimulated learners to articulate their ideas, promoted the development of learners' cognitive skills in critiquing and analysing phenomena, and facilitated conceptual understanding.

Theme 1 Teachers depict real-life scenarios and then use probing and open-ended questions to elicit learners' conceptions that arise from their socio-cultural backgrounds.

One of the patterns that emerged from the lessons showed teachers: firstly, presenting a real-life situation relevant to their learners' backgrounds, and then, eliciting from learners their own conceptions of the scenario. Teachers used open-ended questions that were neutral and invited multiple reasonable answers. For example, when introducing the topic reproduction, Thendo presented a scenario of an infertile woman. She regarded this scenario as relevant in appropriating the socio-cultural knowledge of learners. The teacher tasked learners to think about how infertility affects their communities or families and at the same time how it is handled or solved. This introduction served as a good conduit into discussion on possible physiological reasons for infertility in women.

Infertility is an issue that is relevant to the context in which the learners reside. Relevant content taught in context-based science lessons is an approach designed to engage learners in science learning (Banner 2016). Between 20 and 30 per cent of couples in Africa experience either primary or secondary infertility, and South Africa is referred to as the infertility belt of Africa (Inhorn and Patrizio 2015). In many cultures, more especially African cultures, childless women suffer discrimination, stigma and ostracism. Some learners suggested that the woman's infertility was inflicted upon by witches or that the woman was cursed by her ancestral spirits. The teacher allowed discussion on this belief and then provided leading information intermittently. For example, Thendo added that an examination by the medical doctor showed that both the woman depicted in this scenario and her husband were fertile indicating that her eggs were viable. Thendo did this to redirect learners' thoughts towards the concepts she had planned to teach in this lesson. Thendo asked: "What then could be the reason for this couple's failure to have a child?" The question stimulated learners into a debate and further discussion pursued on factors responsible for human infertility and even queried the beliefs they shared earlier. By providing authentic problems evident in learners' families and communities and at the same time asking open-ended questions, teachers induced cognitive conflict in learners which Kang, Scharmann and Noh (2004) posit as an important precursor for concept formation. Unlike in a conceptual change model where teaching is targeted at causing cognitive conflict between the learners' prior experiences and the new concepts to be learned with the hope of the later replacing the former (Chan, Burtis and Bereiter 1997), learners are not expected to discard their prior knowledge. Rather, cognitive conflict should help learners conceptualise and decide what best explains the situation at hand, their socio-cultural knowledge or the scientific knowledge. This goes back to the authors' argument that integrating learners' socio-cultural background in science teaching provides learners with a holistic lens through which they view science. Thus said, learners not only understand scientific concepts better, but they value and embrace their socio-cultural background.

The socio-cultural knowledge of learners was also evident when the teacher asked learners for suggestions on how the couple could have a child. Some learners suggested that the man should marry the wife's young sister or another woman, a polygamous practice common in African tradition, which learners have witnessed in their families or communities. This is more so for the Zulu culture, one of the ethnic groups learners belong to.

What was also evident from this lesson was that learners possessed alternative conceptions that were strongly rooted in their socio-cultural backgrounds, which when teachers explored helped learners to understand the concepts taught. The use of open-ended questions helped in unearthing these learners' ideas, which would otherwise have gone unnoticed by the teacher. Another example is from a lesson taught by Nhlapo, where a learner asked: "What makes me suffer from period pains sir?" The following are some of the learners' responses:

> **Learner 1** My grandmother warned me against eating some of these modern foods. I believe menstruation helps to clean up the dirt in my body.
> **Learner 2** Menstruation can be a natural process of removing evil spirits from the women's bodies.
> **Learner 3** Oh yes, the woman's womb should be cleaned of the dirt or bad spirits before carrying a baby.

Further, the teacher asked: "How do you explain the source of the dirt and the evil spirits". One of the learners responded: "The dirt is coming from some of the junk food we eat". The other learner said: "The witches place or send the evil spirits to someone they don't like". The learners' responses are an indication of their failure to differentiate between reproductive system and digestive system and at the same time that they believed in witchcraft, which they could blame on any calamity that befalls anyone. The teacher then pointed out the difference in the two systems by using a chart that helped learners discern the difference between the two processes.

It is also interesting to note that during the post-lesson interview, Thendo communicated that she experienced some unease in challenging learners on their cultural beliefs. As an African, she felt it would be inappropriate for her to question learners who maintained that couples without children should seek the spiritual guidance of their ancestors. Similarly, Nhlapo said: "To be honest with you, when it comes to things involving witchcraft, I cannot help the learners much because I also don't understand whether it really happens or not". This reflects that teachers who belong to particular cultural groups may feel conflicted when engaging learners in a discussion which may challenge learners' conceptions that are culturally based. In fact, teachers could be holding the same beliefs, which makes it difficult for them to oppose them on the basis of scientific knowledge.

A point to note from these findings is that there were alternative conceptions that arose from the socio-cultural experiences learners brought to the science classroom. The authors are of the view that the integration of learners' socio-cultural background in science teaching and learning played an important role in unearthing what learners were harbouring, which in instances where teachers are not proactive in asking relevant questions, such ideas would have remained unnoticed. The teachers in the study labelled learners' ideas which do not conform to the general scientific knowledge as misconceptions. A point to note is there is a deficit thinking by most teachers that the knowledge learners bring from their socio-cultural background is responsible for the misconceptions that arise during the teaching and learning process. Instead of interrogating or challenging learners' ideas, teachers should be mindful of the fact that the learners' socio-cultural background provides the innovative, critical thinking and problem-solving skills, which if tapped appropriately could be valuable sources of information. Such an approach counteracts deficit views about the learners' socio-cultural way of knowing where teachers end up being antagonistic to learners' ideas in the science classrooms. Such teacher reactions can be explained by Buxton (2017) who found that teachers' abilities to effectively teach Aboriginal learners were limited in terms of knowledge of learners' culture, suitable pedagogies and ways of viewing and learning. In fact, misconceptions do not only arise from what learners bring to the science classroom, but learners may also acquire misconceptions from textbooks and the teaching and learning process. Therefore, misconceptions from learners should not be a reason for teachers to shy away from integrating learners' socio-cultural background in the science classrooms.

Theme 2 Teachers encouraged argumentation in getting learners to articulate and then justify their worldviews in relation to scientific concepts taught.

When teaching some topics, especially those potentially disposed to alternative worldviews, teachers took the opportunity to facilitate argumentation amongst learners. In doing so, teachers gave learners an insight into the process of scientific argumentation that requires one to evaluate evidence, assess possibilities, establish how valid the claims are, and address counter evidence (Sadler 2006).

The role of argumentation in science learning can be underlined by the statement that "the goal of science must not only be the mastery of scientific concepts but also learning how to engage in scientific discourse" (Bricker and Bell 2008, p. 495). Teachers made use of probing questions such as "Why would you say that? Do you think it is necessary? What are the reasons for your answer?" These were coupled with teachers' statements such as justify your answer; elaborate your reasons; and give us examples. In this way, teachers sustained the arguments and motivated learners to always provide reasons/evidence to support/refute any claims put forward.

In the teaching of the reproductive system, Thendo weaved the issue of male circumcision into the lesson. In some South African ethnic groups in which some learners belonged to such as Xhosa and Sotho, circumcision is rooted in belief systems. It is performed when boys reach adolescence. Every year in South Africa, thousands of adolescent boys are enrolled into initiation schools. Unfortunately, the lives and health of several initiates are compromised when they fail to get medical attention in time for complications such as septicaemia, gangrene, severe dehydration and genital mutilation (Ntombana 2011). For example, young Xhosa (an ethnic group) men in the Eastern Cape, one of the South African 11 provinces, consider circumcision to be an initiation ritual and an important part of the passage into manhood. Thendo initiated discussion by posing the question: "Why is circumcision important in some cultures?" The learners offered responses that were informed by traditional, religious and medical perspectives on the topic. Thereafter, the teacher presented an article entitled: "Mountains of death, the true cost of male circumcision" (Hinis 2015). The learners who assumed a cultural perspective argued that men who chose not to be circumcised could not be regarded as fully fledged members of their culture. Some learners were quite incensed by the article and remarked "ufana nabafazi" meaning you are acting like women. The teacher responded: "What do you mean?" One girl interjected: "But already they are men when they are born".

The class appeared to be quite divided on their views of circumcision. Those opposed to it recounted how the circumcision was conducted by unqualified traditional providers. For instance, learners considered the behaviour of adults who circumcise the boys during initiation as being cruel because of the deaths. Thendo created an opportunity for learners to present their ideas and reasoning for a while, interrupted only when asking questions which provoked further thinking on the issue. For example, at one time she asked: "Can we say they are cruel?" This stimulated further argumentation, with a boy stating his position in his native tongue Sesotho as follows:

> Ma'am, bontate ba tshwanetse go rutiua gore ba tiye ba seke ba tshwarwa go tshwana le bomme ka nako ea lebollo.

The above statement by the boy stresses the importance of men to be trained to toughen up and not be treated with kid's gloves in support of an earlier assertion that the boys who receive medical circumcision are weak. In other words, the learner is opposing the idea which labelled the traditional leaders performing the initiation process as cruel. In fact, this reasoning is in line with African tradition that men are the custodians of security in the homes, protecting the women who are supposedly "weak" and the children. Eventually, a consensus position was reached whereby the learners suggested a collaborative approach in which medical doctors provide some training to the traditional leaders to uphold hygienic practices and provide well-balanced nutrition to the initiates in order to prevent the loss of lives at the initiation schools.

Theme 3 Teachers designed and enacted authentic problem-based activities stemming from learners' socio-cultural backgrounds to promote the development of critical and analytical thinking skills in learners.

Teachers used authentic problem-based learning activities to integrate school science and socio-cultural knowledge from the community. An outcome of this approach was that it required learners to apply critical and analytical thinking. Two cases of such scenarios are now discussed.

An example of how problem-based learning supported critical and analytical thinking was evident in the lesson taught by Nhlapo on the issue of poor nutrition in some traditional meals. The initial discussion showed that some learners who had adopted a Western diet in their nutrition tended to reject traditional African foods. In teaching the importance of a healthy diet, Nhlapo planned an activity where learners engaged particular families in their communities to determine the kind of traditional food they eat. The objective of the task was to establish diets of different cultures and ethnic groups. The learners then collectively compiled this information on a poster where they classified the diets into food types. Table 3 is indicative of a poster from one class.

During laboratory practical, learners performed food tests such as tests for starch, glucose and proteins using some of the traditional food learners brought. This reduced the disconnectedness learners often feel between science and traditional knowledge (Ogunniyi 1988). By using these traditional foods, the teachers created cultural congruity between home and school, thereby making learners feel represented in the science classroom (Aikenhead 2002). There is an argument that learners feel comfortable in using material resources that are found in their homes when learning science because science becomes less abstract (The Commonwealth for Learning 2001 cited in Ramnarain and Fortus 2013). The discussion that followed this exercise revealed that learners acquired a greater understanding of the need to have a variety of foods in their diets. The learners, who were initially cynical towards the nutritional value of traditional African foods, now appreciated the nutritional value of such foods. This is depicted in the learners' responses such as "Haibo (meaning what?) umnqusho (samp) turned blue black with iodine!" Such statements showed how much the learners were surprised by the results. This helped to debunk the belief that Western foods have more nutritional value than traditional African foods. According to the Health Foundation of South Africa (2015), this country is going through a nutritional transition. Because many people have migrated to urban areas, they have adopted a Western way of life and diet which tend to be high in fats sugars and salt. It is unfortunate that some South Africans believe that overweight shows how wealthy and prosperous one is in society.

Table 3 Diet for different ethnic groups that learners compiled

	Carbohydrates	Proteins	Fats	Vitamins	Minerals	Fibres
Traditional Xhosa meal	*Umngqusho* (samp)	Tripe Beans Boiled and salted peanusts	Tripe	*Usenza* (boiled pumpkin)	*Amarhewu* (fermented sorghum)	Roughage from the samp
Traditional Zulu meal	*Uphuthu* (fluffy mealie porridge) *Ubhatata* (sweet potatoes) *Ujege* (dumpling, mixture of flour and mealie meal)	*Izindlubu* (beans) *Amasi* (sour milk)	*Amasi* (sour milk)	*Imbuya* (wild vegetables)	*Imbuya* (wild vegetables) *Amasi* (sour milk) *Amahewu* (fermented sorghum)	*Izinkobe* (boiled maize seeds)
Traditional Venda meal	*Vhuswa* (thick mealie meal porridge)	*Masonzha* (mopani worms)	*Masonzha* (mopani worms)	*Delele* (wild vegetables)	*Delele* (wild vegetables)	*Maphuphu* (boiled maize seeds)

In the second case, Pedro introduced the scenario of egg donation in addressing infertility amongst women and then stimulated discussion on this. He asked learners to discuss the following:

> **Pedro:** It has become accepted in some countries that some women volunteer to provide their eggs for scientists to use in research. What is your view about the practice?

The responses given by learners considered ethical issues, belief systems and scientific knowledge. Some of the learners' argument was that when women donate eggs, their ancestors may take offence and make the women lose their fertility. One boy expressed his fear that the women's eggs may be depleted and leave the women stranded when they decide to fall pregnant. To this, the teacher referred learners to a previous class task where learners calculated the total number of eggs that a woman can produce from the time she is 30 years old until she turns 40 years. The teacher's reference to the previous calculations was meant to indicate to learners that quantity was not an issue at hand. Learners discovered that before making any reasonable judgements or decisions, one has to collect sufficient information. The teacher asked, "If there are no egg donations, how can scientists research on reproductive diseases?" The question was meant to trigger learners to discuss and stimulate critical thinking. Learners engaged with the issue from both scientific and traditional perspectives, in acquiring a more nuanced and holistic understanding of the issue. Through such integrated questioning techniques, which required learners to analyse both scientific and traditional practices, Pedro engaged learners actively in discussion, challenging them intellectually and promoting learners to thick critically. His teaching was focused on the learning process, and not necessarily on the content—developing learners' higher-order thinking skills by evaluating the authenticity of information before accepting it.

> **Theme 4** Teachers used code switching between English and the learners' indigenous languages to facilitate conceptual understanding.

Figure 1 shows the study's conceptualisation of different aspects of learners' socio-cultural backgrounds; language is included. Language has been conceived as the greatest barrier to learning science when the language of instruction differs from learners' indigenous languages (Meyer and Crawford 2011). In most of the lessons, the researchers noticed how learners communicated with each other freely when using their home languages in group discussions in the science classroom. The teachers practised code switching between English and the learners' indigenous languages when explaining science concepts. The teachers regarded code switching as important for effective teaching and learning. When asked to justify this practice, Nhlapo responded: "It helps me in explaining using learners' home languages since most of the learners do not understand much English". As a result, it was evident that learners' thought processes were enhanced due to code switching, especially that language is not just a means of communicating and interacting, but it is also a medium used for thought and reasoning (Bloom and Keil 2001).

During interviews, teachers mentioned the challenges they faced when trying to explain some science concepts using learners' home languages. This is because there are certain terms in science which have no equivalent words in vernacular. The teachers gave melting and smelting as examples of such terms which are represented by one word *ukhuncibilika* in IsiZulu and IsiXhosa. The word *chaza* in IsiZulu may either mean define or explain, which makes it difficult for teachers to code switch when referring to such terms in their instruction. Accordingly, teachers tended to use examples that the learners are familiar with in their daily lives. The following is an example of how one of the teachers used exemplification in differentiating the two processes, melting and smelting.

> **Nhlapo**: In explaining melting I usually ask learners to describe how the ice cream they normally buy during break or lunch times behaves when placed in their mouths or when it is left outside the refrigerator, which signifies the process. On the other hand, I bring out the meaning of smelting by referring learners to the activities that the people who make burglar bars, which is a common entrepreneurial practice in the townships. I would ask them to observe what happens when metal rods are placed under intense heat.

In essence, teachers readily adopted code switching, and when direct translation was not possible, they drew examples from the everyday experiences of learners to support the understanding of scientific concepts. The findings are evident of how the use of vernacular languages can be limited during the teaching and learning of science. This problem is not because the indigenous languages are deficient of vocabulary, but rather the authors view it as a systemic problem in the education system. There are no teaching and learning materials written in learners' indigenous languages in the South African science curriculum, and as such, no concerted research has been done to translate scientific words and processes into learners' indigenous languages. It should also, however, be noted that every language, English included, has deficiencies. In this case, teachers tapped on their pedagogical skills of using examples to explain concepts to learners.

In the following excerpt, Pedro, one of the teachers, laments how language acts as an impediment in his science classes.

> **Pedro:** It reminds me of last year when I asked my learners about the purposes of reproduction and their answer was, its meant to grow their surnames. It came as a surprise because previously we had discussed how reproduction ensures continuation of species, to avoid extinction. According to learners, growing surnames meant increasing members in their families.

Precisely learners understood the purpose of reproduction but could not explain it in the appropriate language, which showed their limitations in the language of teaching and learning.

Perspectives on research findings

The research findings showed how contextualised and relevant science teaching and learning in high school can be achieved by incorporating learners' socio-cultural backgrounds. Science teachers tapped into the socio-cultural backgrounds of learners that encapsulated their experiences, beliefs and cultural practices. Similarly, previous authors found that teachers who are aware of the circumstances in which their learners are living in are capable of identifying appropriate teaching and learning strategies and resources that interest the learners (e.g. Suh 2005). On that note, Lemke (2001) posits that science concepts should be taught based on learners' contextual background to ensure meaningful learning.

The use of open-ended questions in brainstorming on real-life scenarios enabled teachers to elicit learners' conceptions that arise from their socio-cultural backgrounds. It was evident that learners held conceptions of phenomena grounded in their socio-cultural practices and beliefs, which at times were at odds with Western scientific knowledge. For instance, the belief that women who fail to conceive are bewitched or cursed by ancestral spirits prevents the learners from accepting the biological causes of infertility. This is because such beliefs defy Western scientific knowledge and reasoning. Such dissonance in worldviews has been found to create difficulties for learners to understand scientific concepts (Eniayeju 2010). As such, learners become confused as to what to follow or believe. The authors' stance in this matter is that exposing learners to articulate their belief systems in the science classroom enhances learners' self-esteem and social identity amongst other benefits. This is so whether their belief systems or science supports or does not support each other. The argument is that science knowledge and IK are two knowledge domains in their own right, which should not be expected to always converge and agree about each phenomenon. This confirms Oruka (2002)'s argument that IK has both critical and uncritical elements, and in this case, belief systems and customs are accepted without question. Indeed, learners' perceptions and how they create knowledge are shaped by their worldviews (Keane 2008). The ultimate goal is to develop learners who are knowledgeable about both knowledge domains, science and IK and be able to utilise such knowledge for the betterment of society. This concurs with Keane (2008) who urged teachers to produce graduates with deeper understanding of both Afrocentric and Western worldviews.

The use of real-life scenarios and probing questions invoked learner articulation of their prior knowledge, which Duit (1996) realised could either enhance or impede learning and understanding of science concepts. The questions the teachers asked helped in exploring, challenging, revising and restructuring learners' worldviews and science knowledge during teaching. As such, both the learners and the teachers helped each other in constructing meaning and knowledge, which has been found to be the greatest benefit of such social interaction (Schwandt 1994). These strategies enabled learners to cross boundaries from ideas that have no scientific bearing to correct scientific concepts (Hipkins et al. 2002), and at the same time, learners realised how science knowledge cannot explain some of their important belief systems, which inform their being. Teachers should therefore be cautioned from forcing learners to discard their worldviews just because they do not "fit" into the scientific realm of knowledge. As argued earlier on, science and IK should not be viewed as competing. IK forms learners' cultural commodities, their forms of capital that should be respected and valued (Seiler 2001). Rather, an important benefit of integrating IK and science is to enhance cross-cultural understanding and tolerance in learners and ultimately view things from multiple perspectives. The teaching and learning process should help learners discern for themselves the limitations of both science and their indigenous knowledge. None of the knowledge domains should assimilate the other (Mboya 1999). In fact, Barnhardt and Kawagley (2005) brought in an important aspect of the integration between IK and science when they said that the integration should be used in a complementary way. With such a stance, IK will contribute towards science and the reverse will be true. Of note is the application, learning through experience and the utility value that IK brings to the fore that can contribute towards effective teaching and learning of science. Barnhardt and Kawagley (2005) explained clearly how competency of indigenous knowledge is assessed through practical experience in a real context where they described the lack of attainment of it as life threatening, since the knowledge ensures everyday survival. This is unlike assessment of science knowledge, which is done through some objective tests, which do not test the individual competency in using science knowledge. Another important aspect of IK that learners and teachers can benefit as a result of the integration with science is that IK provides an experientially grounded, holistic worldview (Barnhardt and Kawagley 2005). This is unlike the tendency to compartmentalise knowledge that is typical of science.

Thus said, this brings in the argument that indigenous knowledge is also scientific. An example is the ability by indigenous people to make detailed observations about animal and plant behaviour, which can then be used to predict weather, rainfall patterns and inform on the agricultural activities. When integrating the two knowledge systems in the science classrooms, teachers should therefore not be apologetic or doubt the contributions or worthiness of indigenous knowledge in developing learners scientifically. Hence, IK and science are not two disparate and incompatible knowledge systems.

The teachers' use of argumentation helped in promoting learner articulation and explication of their worldviews in relation to Western scientific concepts taught. Contrary to the view that the strategy does not conform to African ways of learning (Hewson 2015), learners actually managed to evaluate their belief systems against Western scientific knowledge and vice versa, which created learning opportunities in the classroom. In fact, this discourse was in line with traditional African styles of discussion and debate where the focus is on building consensus (Easton 2011). What was significant during this argumentation was that the teacher facilitated the discussions between the learners, ensuring that insights were shared and opinions evaluated before reaching consensus. This is consistent with the assertion that argumentation stimulates interaction and discussion in the science classroom (Ogunniyi 2004). Because of the enhanced classroom interactions, learners reflected on their pre-instructional conceptions and realised how less viable they were which paved way for negotiation and reformulation of new ideas and shared meaning (Kearney 2004). Unlike other findings that suggested that teachers and learners, who were strongly influenced by their traditional and religious backgrounds, had difficulty in discussing human reproduction (Doidge and Lelliott 2010), the current study met with success in this regard. The current study indicated that when learners' socio-cultural background is incorporated in science teaching and learning, the interactions between the teacher and learners and amongst the learners themselves is improved greatly. In this way, teachers create classroom environments conducive to communication and interactions, which has been described as resembling family-like settings (Garcia 1993). Such classroom situations accord learners an opportunity to speak out their ideas freely.

It should, however, be noted that the argumentation was a success in these instances probably because learners were forthcoming in understanding and accepting each other's point of view. It could be that some learners failed to pursue their counter arguments, and as such, they were quick to be convinced. A point to note is that these are young learners in their second year of high school who have not gained adequate skills of argumentation. Language could have played a role in controlling the extent of argumentation considering that they were mostly English second language speakers where the use of home language was sparsely allowed. The authors have the view that in a class of mature learners, argumentation may display unAfrican tendencies where confrontations could ensue. This is evidenced by one such case where learners in the current study echoed emotional statements in an effort to defend their cultural practice of undergoing initiation against those who opt to undergo medical circumcision. Discontentment, resentment and animosity may arise in a classroom with diverse learners' socio-cultural backgrounds. This is because during argumentation, learners are in pursuit of making sense and persuading others (Berland and Reiser 2009). Teachers should therefore guard against lengthy argumentation in the science classrooms and identify carefully areas to utilise argumentation as a teaching strategy.

By using open-ended questions teachers stimulated learners to think and reason scientifically, for example, the question: "How do you explain the source of the dirt"—a question directed to a learner who showed confusion between the digestive and reproductive system—required learners to explore their views deeply. The benefits of using open-ended questions in facilitating learners' reflection on discovered or recognised ideas have been noted by other authors (e.g. Harlen and Qualter 2004). On that note, Walsh and Sattes (2005) noted that when teachers ask quality questions, learners are encouraged to deeply reflect and critically think about the concepts being discussed.

By using code switching between English and the learners' indigenous languages, teachers facilitated conceptual understanding of Western science. The importance of language and talk in a science classroom cannot be overemphasised, as this supports learner development of science concepts and allows for deeper understanding (Scott, Asoko and Leach 2007). Teachers' explanation of the scientific concepts in both languages enabled learners to understand the scientific concepts better, as found in other studies (Lim and Presmeg 2011). Learners were more interactive and forthcoming in sharing their ideas. It could be that the learners felt recognised as part of the science learning community. This could be consistent with what has been said about the use of learners' home languages as a tool to create greater cultural congruency in classroom science instruction (Lee and Luykx 2007). Cultural congruency refers to teachers' integration of scientific concepts to be learnt with learners' linguistic and cultural experiences to promote learner achievement (Lee 2004).

Is cultural diversity in science classrooms a reality?

Given that learner cultural diversity in science classrooms is a permanent reality and that matching teacher's background with learners' backgrounds is impossible (Lee and Luykx 2007), two important implications can be drawn from the current study. The first is for teacher professional development programmes to address the beliefs and practices teachers hold regarding the diverse learners they encounter in their classrooms in relation to science as a subject. Because teachers graduate with underlying beliefs that can sometimes defeat the goal of providing equitable education for all learners (Bryan and Atwater 2002), they should be made aware of how such beliefs influence their pedagogy which may function to marginalise certain cultural groups of learners and limit their learning opportunities. Therefore, teachers should be equipped with knowledge and pedagogical skills appropriate for multicultural science classroom settings. The study findings elucidate some of these skills that should form part of science teachers' repertoire. Secondly, these results can form a reference for teaching socio-culturally diverse and economically disadvantaged learners in meaningful ways while incorporating their socio-cultural backgrounds. This can be regarded as a guideline that can be followed by teacher education institutions to enable all learners from socio-economic and cultural diverse backgrounds comprehend science meaningly.

The three teachers, Thendo, Pedro and Nhlapo, incorporated learners' socio-cultural backgrounds in different ways, which improved the teaching and learning environment. Border crossing from learners' worldviews to Western science knowledge was made easier by these pedagogies, which encouraged learners to find meaning in and engage with science. The teaching strategies employed acted as bridges that scaffold the connection between the concepts learned and the learners' socio-cultural backgrounds. From the findings, one cannot make the assumptions that learners' beliefs were changed during this process, but rather learners managed to reconcile their belief systems with newly acquired scientific concepts, which should be the case. Further research could involve investigating how professional development programmes could equip pre-service teachers with the skills required to incorporate learners' socio-cultural practices, experiences and beliefs into science teaching. The study therefore presents possibilities of how learners' socio-cultural background can be incorporated in the science classroom.

In conclusion, the study utilised the strength of learners' socio-cultural practices, experiences and beliefs to invoke meaningful classroom interactions that allowed exploration of scientific concepts. The teachers achieved this through the use of (1) real-life scenarios coupled with probing and open-ended questions to elicit learners' conceptions; (2) argumentation in getting learners to articulate and then justify their worldviews in relation to scientific concepts and vice versa; (3) authentic problem-based activities stemming from learners' socio-cultural backgrounds; and (4) code switching between English and the learners' indigenous languages.

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Lydia Mavuru is a senior lecturer in science education at the University of Johannesburg, South Africa. Her main research interest is socio-cultural perspectives in science education focusing on social constructivist pedagogies and consideration of equity and diversity in making science comprehensible and relevant. Her thrust is the incorporation of learners' Indigenous Knowledge Systems (IKS) and teacher efficacy in IKS integration in the science classroom.

Umesh Ramnarain is a professor in science education at the University of Johannesburg, South Africa. His main research interest is on inquiry-based science education, with a particular focus on its uptake in South African classrooms, where the unequal funding policies of the previous Apartheid education system have resulted in learning contexts that are complex and diverse.